A National Energy Efficiency Data Center: Removing the Curse of Invisibility

Presented at Modeling Workshop

Energy & Economic Policy Models: A Reexamination of Some Fundamental Issues

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Example (1) of why energy efficiency data is needed

The New York Times, October 16, 2006

Grid Watchdog Warns More Power Is Needed

WASHINGTON (AP) -- The power sector's reliability is on course to worsen over the next decade as electricity demand outpaces the addition of new power-generation capacity, the group that oversees North America's grid said in a report issued Monday.

The North American Electric Reliability Council, appointed by the federal government to be the nation's power-grid watchdog, said that in the next two to three years the power-supply cushion in Texas, New England, the mid-Atlantic, the Midwest and the Rocky Mountain regions will drop to unhealthy levels.

With demand for electricity expected to rise by 19 percent by 2015, and generation capacity on pace to grow by just 6 percent, "the adequacy of North America's electricity system will decline unless changes are made soon," the council's president, Rick Sergel, said in a report released Monday.

In addition to building more power plants, companies need to upgrade transmission systems, improve energy efficiency programs for businesses and consumers and prepare to replace an aging work force, the council said (*italics and emphasis, mine*).

Example (2)

from the website of

The Alliance for Energy and Economic Growth

(yourenergyfuture.org)

The Alliance for Energy and Economic Growth keeps policymakers up-to-date with the latest energy information. Following are basic statistics on integral aspects of the energy industry.

Energy Supply and Demand - The demand for energy of all forms is likely to increase significantly, according to the Energy Information Administration. By 2030, ***even with expected dramatic gains in efficiency***, total energy consumption is forecasted to increase by 34 percent, petroleum by 34 percent, natural gas by 20 percent, coal by 53 percent, and electricity by 40 percent (*italics and emphasis, mine*).

Energy Efficiency (EE) is an invisible resource

- The inability to *see* energy efficiency at the national level can lead to sub-optimal resource allocation decisions at the national level. In fact, as a potential energy resource, the reserves of energy efficiency grow larger every day – yet, in aggregate, they are largely unacknowledged and unseen
- They will remain unseen unless there is a coordinated public effort to make them visible, because seeing the national EE picture is in no one's private interest – it is a public good
- This is particularly ironic because the private and public sectors have invested 10's of billions of dollars in EE in the past 30 years, and through individual program evaluations and local studies, the indications are that on the whole, EE investments have been highly cost-effective
- but nationally, the blind spot is huge

Invisibility leads to statistical bias as well as policy bias

- In modeling, invisibility is tantamount to setting all the values of variable to zero
- If the invisible variable is an explanatory variable that is correlated with other explanatory variables, its absence will cause a model's error term, which is supposed to be independent, to be dependent on the movements of the remaining explanatory variables
- Consequently, all of the model's estimates will be biased and inconsistent
- This means that not only will energy efficiency be ignored, but all of the other explanatory variables will be misrepresented in how they relate to energy use

An example of model specification error is provided by an analysis contained in a recent study of mine. In it, a fixed effects model of commercial sector electricity intensity was estimated for 42 states over a 13 year period, from 1989 through 2001. In addition to various other market-related determinants, the model contained a national time trend variable, referred to as *INFOX*. It is the FRB market group index of production of information processing equipment for businesses.

The table below contains the commercial sector model coefficients related to *INFOX* as well as two public program variables, referred to as *DSMX1* and *MTX*. The former represents annual state-level energy savings due to commercial sector DSM programs, and the latter is a proxy for national energy savings from publicly-funded market transformation programs. The columns marked A, B, C, and D contain the variables' coefficients, with standard errors in parentheses, estimated under different model specifications.

Real-life examples of the dangers of EE invisibility

M. J. Horowitz, "Electricity Intensity in the Commercial Sector: Market and Public Program Effects," *The Energy Journal*, Vol. 25, No. 2, p.126

Variables	**(A)**	**(B)**	**(C)**	**(D)**
INFOX	-0.0060	-0.0037	0.0077	0.0048
	(0.0030)	(0.0033)	(0.0041)	(0.0046)
DSMX1	--	-0.0033	--	-0.0025
	--	(0.0006)	--	(0.0007)
MTX	--	--	-0.0076	-0.0050
	--	--	(0.0014)	(0.0018)
Adj. R2	0.69	0.68	0.69	0.68

As can be seen, each of the model specifications attain a virtually identical R-squared compared to the full model, designated as model (D). However, in model (A) both public program variables were excluded, and in models (B) and (C) one of the two public program variables is excluded. This suggests that the R-squared statistic is not a reliable indication of the quality of the models or of specification error. What is telling is that the coefficient of *INFOX* -- which measures the impact of electronic equipment on electricity intensity – changes dramatically in models (A), (B), and (C) when one or both public policy variables are dropped from the full model. As well as switching signs in two of the three abbreviated models, the statistical significance of the coefficient changes back and forth. Equally noteworthy, the magnitudes of the public policy coefficients change when one or the other is excluded from the model.

Another version of the curse of invisibility

Loughran, David S. and Jonathan Kulick (2004). "Demand Side Management and Energy Efficiency in the United States." *The Energy Journal*, 25(1):19-43.

Table 3. Effect of Energy Efficiency Expenditures on Utility-Level Electricity Intensity

	Specification				
	(1)	(2)	(3)	(4)	(5)
DSM_E	0.0003	0.00001	0.0005	-0.0027	-0.0039
	-0.001	-0.001	-0.0008	-0.0018	-0.0024
DSM_E(-1)	-0.0007	-0.0004	-0.0016	0.0016	0.0054
	-0.0011	-0.0011	-0.0012	-0.0021	-0.0029
DSM_E(-2)	-0.0005	-0.0002	0.0005	-0.0007	-0.0025
	-0.0005	-0.0006	-0.0007	-0.0011	-0.0015
Dt CUST	0.9691	0.9282	0.7871	0.7756	0.6446
	-0.1493	-0.1428	-0.1384	-0.0926	-0.0698
Dt MWH_I	0.6784	0.6128	0.9347	0.5734	0.675
	-0.2021	-0.199	-0.1908	-0.3436	-0.3046
Dt MWH_C	0.371	0.3235	0.7188	0.3249	0.4501
	-0.1987	-0.1959	-0.2032	-0.3107	-0.3229
Dt GSP	0.0322	0.0225		0.0492	
	-0.0164	-0.0218		-0.0195	
Dt P_ES	-0.1012	0.0662		-0.1298	
	-0.0553	-0.0741		-0.0721	
Dt P_NG	-0.0233	0.0393		-0.0629	
	-0.0229	-0.0323		-0.0344	
Dt P_CL	-0.0278	-0.0174		0.0143	
	-0.0215	-0.014		-0.027	
Dt P_PA	0.0887	0.1035		0.1493	
	-0.0509	-0.0397		-0.0574	
Dt CLIMATE	0.1496	0.2237		0.211	
	-0.0359	-0.0392		-0.0408	
Year effects	x	x	x	x	x
State-specific quadratic		x			
time trend					x
State-year fixed effects			x		
n	1,815	1,815	2,373	774	998
R 2	0.54	0.571	0.675	0.598	0.769
Prob > F	0.002	0.178	0.024	0.024	0.168
Predicted Dt MWH	-0.004	-0.003	-0.003	-0.012	-0.006
Predicted $DSM_E /kWh	0.137	0.223	0.169	0.064	0.119

Models (4) and (5) have 119 utilities reporting non-zero EE expenditures in every year. Model (4) goes to 1997 and model (5) goes to 1999.

However, no data were available for GSP, the 4 energy prices, or climate, beyond 1997 – so model (5) is estimated without these variables.

In model (4), L&K estimate that the average DSM cost of reducing a kWh is 6.4 cents. In this model, all 6 variables (later dropped) are statistically significant at near or above the 95% level.

In model (5) the average DSM cost of reducing a kWh is 11.9 cents, almost twice as much. Note the higher R2 for model (5)...

QUESTION: Which model should be trusted, the one with the missing variables or the one with the fewer years?

ANSWER: In my opinion, the one with fewer years is far more reliable than the one with the missing variables. Based on my calculations, it implies a DSM realization rate of 57%, well in line with several other studies. The omitted variables model yields a DSM realization rate of 27%.

Invisibility weakens the case

- Large areas of the academic literature neglect the role that public policy plays in shaping private sector energy use, e.g.,

  1. Big-picture studies:
     a) energy-GDP relationship
     b) environmental Kuznets curve
     c) energy price elasticities
     d) technological change

  2. Little-picture studies:
     e) discrete choice analysis of equipment purchases
     f) consumer discount rates, lifecycle costs, uncertainty
     g) market penetration
     h) self-selection, free ridership, spillover

- Neglect leads to models that cannot see what might be predictable changes in the structure of markets, or what might be solutions to important problems

What's not being seen...
what are the most critical EE data needs?

- The two most critical energy efficiency-related variables that are lacking at the aggregate level are:

  1. the ***supply*** (or quantity) of energy savings, in Btu, purchased via public funds and policies

  2. dollar expenditures or ***costs*** of these resources

- These data need to be available by time period, economic sector, and fuel type. Unfortunately while it is easy to define what these elements are, collection of these data is a very difficult task

Absence of *supply* data is ironic

- Currently, it is likely that publicly-funded energy efficiency make available a substantial number of Btu's to the national energy supply
- Electricity generation is a case in point -- why overlook the fact that petroleum, as an input, was responsible for generating 3.4 percent of all the MWh in the US in 2001, while energy efficiency programs were responsible for the ***ungeneration*** of probably much more than 3.4 percent of all MWh in the US in 2001
- If oil is viewed as important for satisfying electricity demand, why isn't energy efficiency?

U. S. electricity generation by fuel source (2001)

Fuel Source	Generation (MWh)	Fuel Share (%)
Coal	1,903,379,549	0.510
Petroleum	127,628,606	0.034
Natural Gas	629,200,576	0.169
Other Gases	13,766,927	0.004
Nuclear	768,826,308	0.206
Hydroelectric	207,548,409	0.056
Other Renewables	78,916,149	0.021
Other	4,254,182	0.001
Total	3,733,520,706	1.000

Source: EIA, Electric Power Annual

EE *cost* data is more complex than it appears

- collecting data on the physical volume of a resource and its consumption is only half the story, the other being the cost of the resource
- the federal government closely monitors the costs of the major fossil fuel sources for generating electricity, i.e., coal, petroleum and natural gas
- note the importance of "standardizing" the cost

Standardized cost of fossil fuel in 2001 (cents per MBtu)

Table 2: Standardized Cost of Fossil Fuel in 2001 (Cents per MBtu)

Division/State	Coal	Petroleum	Natural Gas
Middle Atlantic	144.1	354.9	415.4
New Jersey	233.2	454.0	302.5
New York	142.2	353.7	415.0
Pennsylvania	122.7	372.9	851.4
East North Central	120.8	487.9	405.1
Illinois	119.6	582.9	384.6
Indiana	113.6	585.5	511.5
Michigan	127.5	433.5	382.7
Ohio	131.9	608.5	810.0
Wisconsin	104.7	645.7	478.8
U. S. Total	**123.3**	**397.2**	**457.2**

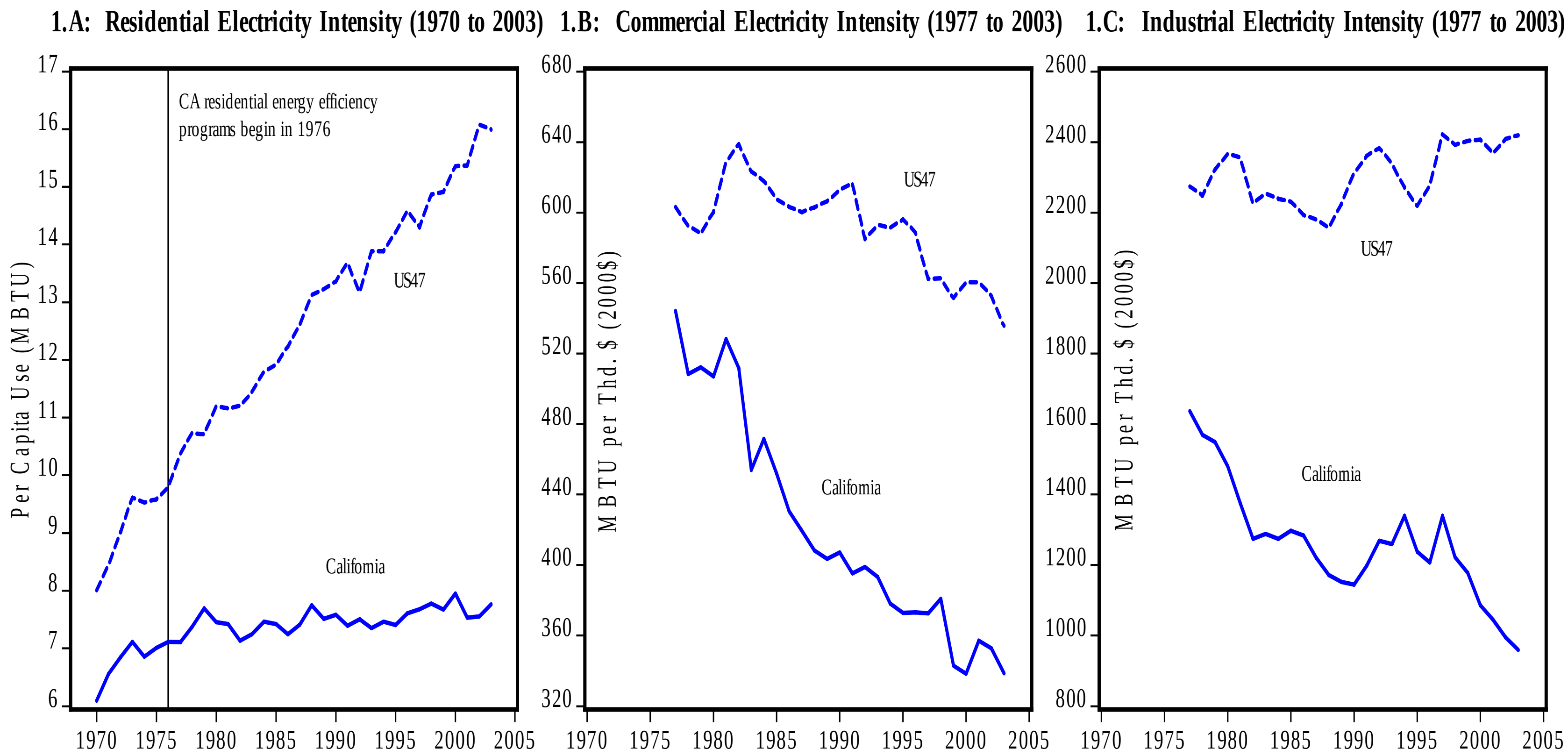
Source: FERC Form 423

since EE is a *nega-fuel*...what are its specific costs?

- Observe that the approximate average U. S. cost of petroleum for electricity generation in 2001 was 1.3 cents per kWh. By now this may be double. This is simply the cost of the raw input, excluding fixed capital costs, transmission and distribution
- Yet the costs of energy efficiency -- which admittedly can range from less than 1 cent per kWh to over 15 cents per kWh, depending on the program and whether private and public costs are included -- is always a “delivered” cost
- Might it not be useful to unbundle delivered EE costs as we unbundle the delivered costs of electricity? What is the T&D value of a saved kWh, versus its fuel value, by state
- Such a breakdown might provide better information for public resource allocation and private investment

Many complex questions go unanswered...

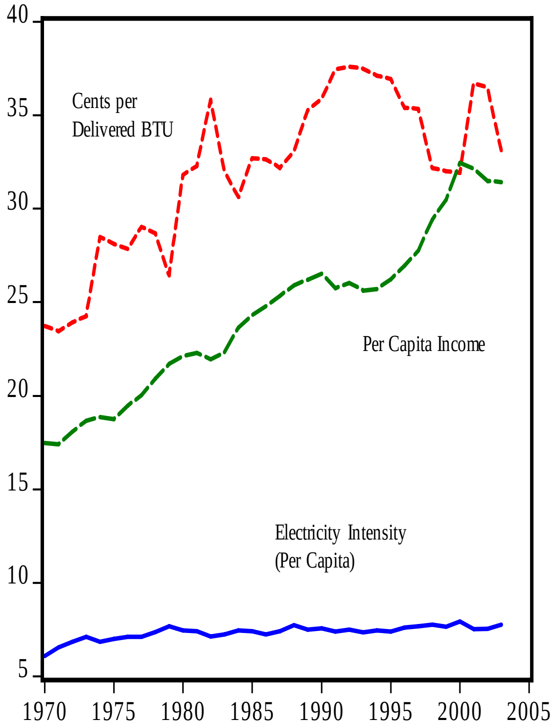
- which sectors show the most change?
- how do government policies affect use?
- what structural changes are taking place?



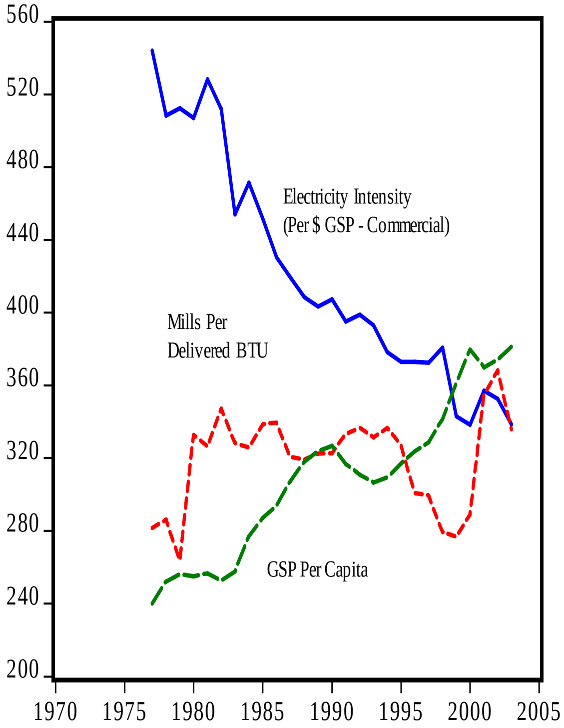
Many state issues can be addressed...

- CA trends – how do they compare with other states?
- how do state prices, GSP, other market variables, affect use?
- has there been market transformation in CA?

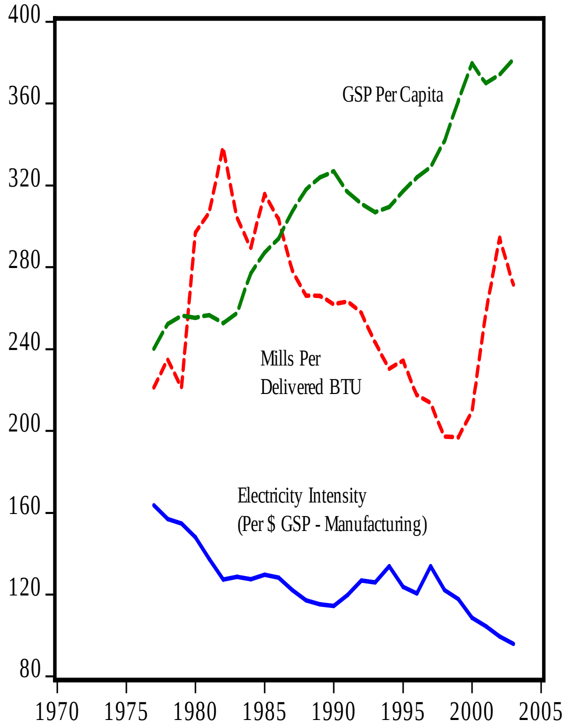
2.A: Residential (1970 to 2003)



2.B: Commercial (1977 to 2003)



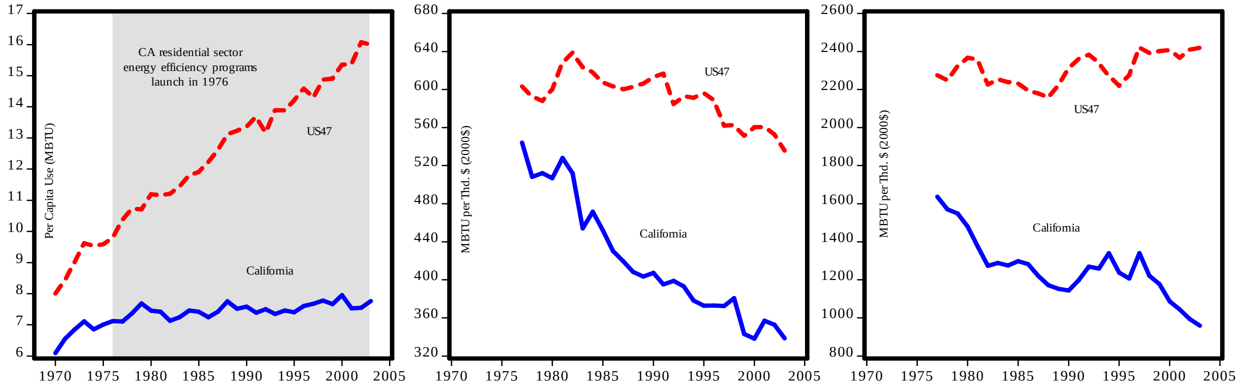
2.C: Industrial (1977 to 2003)



"You mean I was right?"
(Art Rosenfeld, August 2006, private conversation)

Not for attribution. Unpublished results from M. J. Horowitz, "Changes in Electricity Demand in the United States from the 1970s to 2003."

1.A: Residential Electricity Intensity (1970 to 2003) 1.B: Commercial Electricity Intensity (1977 to 2003) 1.C: Industrial Electricity Intensity (1977 to 2003)



California, only	Level of Electricity (GWh) Use			Electricity Intensity		
Sector	Base	Treatment	% Change	Base	Treatment	% Change
Residential (base70)						
Factual (CA)	44,049	73,474	66.80%	7.0	7.6	9.0%
Counterfactual (CA)	50,665	106,183	109.58%	8.0	11.0	36.7%
95% C.L. (+/-)	*22.37%*	*8.21%*		*10.2%*	*3.4%*	
Net Impact			-42.77%			-27.7%
Commercial						
Factual (CA)	72,142	95,474	32.34%	464	367	-20.9%
Counterfactual (CA)	103,391	165,757	60.32%	645	634	-1.7%
95% C.L. (+/-)	*21.65%*	*32.69%*		*3.5%*	*5.3%*	
Net Impact			-27.98%			-19.3%
Industrial						
Factual (CA)	52,547	57,319	9.08%	1,328	1,214	-8.5%
Counterfactual (CA)	99,777	154,752	55.10%	2,512	3,108	23.7%
95% C.L. (+/-)	*22.45%*	*34.38%*		*2.8%*	*4.0%*	
Net Impact			-46.02%			-32.2%

What databases are currently available?

Without going into the gory details...

- Of course, Form EIA-861
- At the local level, most of the data are specific, related to local energy efficiency program, participants, or technologies
- At the regional and federal level and lab level, the databases are spotty, and/or non-specific, and/or unreliable
- Not-for-profit data collection is hit-or-miss depending on project funding, i.e., ACEEE, RFF, ASE

- Nadel, Geller, et al. did some DSM program cataloging in the 1980's
- Many failed attempts in the 1990s, e.g., EPRI, DEEP
- Rosenstock for EEI in 2005 a recent electric utility catalog
- Kushler and York state scorecard for the past few years

NEEDC

- NEEDC will collect and archive annual, state-level data related to energy efficiency and their impacts on markets
- Whether EE policies and programs originate nationally, regionally, or locally, the unit of observation of most importance will be the 50 states. This makes the data collection tractable and permits all the EE data to be meshed with the SEDS, GDP, and NIA datasets, all of which are annual and state level
- To standardize the data, there will be considerable experimentation, modeling, and data-synthesizing
- NEEDC will regularly publish energy and environmental indicators, will provide assistance to large scale modeling efforts, and will cooperate with those wishing to undertake in-depth academic studies

NEEDC funding – an example of what's possible through our Federal Government

The New York Times, October 4, 2006

Software Being Developed to Monitor Opinions of U.S.

WASHINGTON, Oct. 3 — A consortium of major universities, using Homeland Security Department money, is developing software that would let the government monitor negative opinions of the United States or its leaders in newspapers and other publications overseas.

Such a "sentiment analysis" is intended to identify potential threats to the nation, security officials said.

Researchers at institutions including Cornell, the University of Pittsburgh and the University of Utah intend to test the system on hundreds of articles published in 2001 and 2002 on topics like President Bush's use of the term "axis of evil," the handling of detainees at Guantánamo Bay, the debate over global warming and the coup attempt against President Hugo Chavez of Venezuela.

A $2.4 million grant will finance the research over three years.

Most economists support public funding for *A Public Good*

National intelligence delivers ubiquitous benefits that no one in our nation can be excluded from -- and which costs the same to collect whether it benefits 30 million people or 300 million people

At least in theory, this justifies to economists the spending of public monies

Of course, economists may not agree on whether or not the consortium actually increases or decreases national intelligence. According to the NYT, the funding is for the development of software that,

*"...would need to be able to distinguish between statements like **"this spaghetti is good"** and **"this spaghetti is not very good — it's excellent,"** said Claire T. Cardie, a professor of computer science at Cornell."*

example of discriminating software...

This spaghetti is good

This spaghetti not very good – its excellent

"In A Saddle With Death" (1971)

which translates to Homeland Security threat levels...

Free ridership

Spillover

What are some of the *Public Goods* aspects of NEEDC

- ***Energy efficiency*** is just another way of saying ***energy productivity*** – and productivity is the key to a growing economy. The private sector collects EE data, but often this is industry-specific and proprietary. And so, the federal government takes on the mission of collecting productivity data of all sorts, and funds productivity research so as to:
  - better understand economic forces
  - assist national industries in being competitive
  - avoid shortages and to keep prices down
  - better plan domestic and foreign policies
- ***Environmental externalities*** are a concern not only in the US, but throughout the world
- ***National security*** has been linked to energy supplies at least since the Eisenhower administration

On the other hand, despite it being *A Public Good*, there are reasons why our Federal Government will not, and should not, create NEEDC

- Energy policy is highly politicized -- there would be unpleasant opposition and quid pro quos
- Implementing programs is a higher priorities than program monitoring and data reporting
- The federal budget deficit makes new programs and increased spending highly improbable
- Existing DOE and EIA efforts to collect and analyze energy efficiency data are overburdened and of limited scope

NEEDC funding

- Hundreds of individual energy efficiency program evaluations are completed each year – at an approximate cost, conservatively, of $30 million a year (3 percent of one billion dollars in energy efficiency program spending per year, on average).

- Most of the findings indicate that the programs achieve their goals and are cost-effective. Moreover, program benefits are probably underestimated because the evaluations are narrow and do not include out-of-service-territory spillover

- These evaluations are uncoordinated with each other, and often duplicative from year-to-year and from service territory-to-service territory

- I propose an "***EVALUATION SABBATH***" – with the unused funds going to NEEDC. I believe this will be a highly cost-effective use of funds by providing the states with a substantial amount of information about their own states, as well as others, that they currently do not have -- and will never otherwise attain

NEEDC issues requiring discussion and debate

- What are the most critical data needs for policy development?
- What are the most critical data needs for quantitative modeling?
- What indicators or indexes of *realized* and *potential* energy efficiency would be most useful for policy development, planning and evaluation?
- Should the energy efficiency data, and various indicators and indexes, be coordinated with international efforts?
- How should the data be collected, at what frequency and level of granularity?
- How should the data be standardized and quality-controlled?
- What should the formal reports consist of?
- How should the data be made available to the public?
- What other activities should the data center undertake?
- How should the data center be funded?